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(71) Applicant (*for all designated States except US*): ENVEN-  
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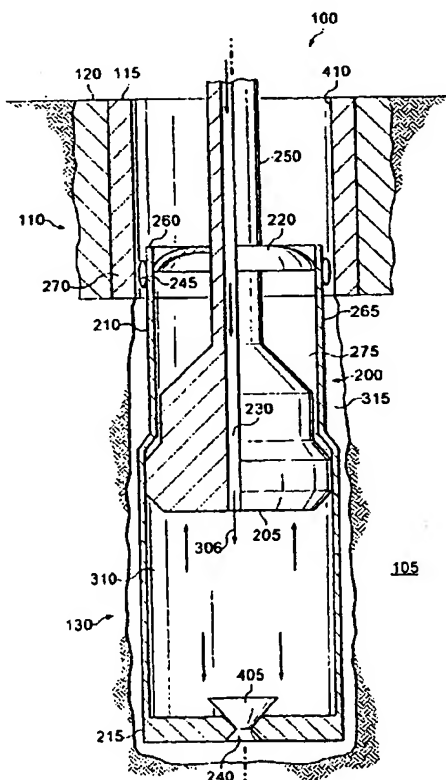
(72) Inventors: and

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[Continued on next page]

(54) Title: SELF-LUBRICATING EXPANSION MANDREL FOR EXPANDABLE TUBULAR

(57) Abstract: A self-lubricating expansion mandrel (205) includes  
a system for lubricating the interface between the self-lubricating ex-  
pansion mandrel (205) and a tubular member (210) during the radial  
expansion of the tubular member (210).



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# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US03/25675

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : E21B 23/00, 43/10

US CL : 166/207, 55.7

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 166/207, 55.7, 50, 55, 55.1, 205, 209, 216, 242.1, 297, 380, 384

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
Please See Continuation Sheet

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2002/0062956 A1 (MURRAY et al.) 30 May 2002 (30.5.2002), whole document	1-9
Y		10-23
Y	US 5,014,779 A (MELING et al) 14 May 1991 (14.05.1991), column 3, lines 31-36	19-23
Y	US 4,526,839 A (HERMAN et al) 2 July 1985 (02.07.1985), column 5, line 60- column 6, line 16.	10-18, 23
A	US 6,325,148 B1 (TRAHAN et al) 4 December 2001, (04.12.2001), whole document	1-23
A	US 3,203,451 A (VINCENT) 31 August 1965 (31.08.1965), whole document.	1-23
A	US 6,158,963 A (HOLLIS et al) 12 December 2000 (12.12.2000), whole document.	1-23
A	US 4,505,987 A (YAMADA et al.) 19 March 1985 (19.03.1985), whole document.	1-23

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

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**INTERNATIONAL SEARCH REPORT**

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**Continuation of B. FIELDS SEARCHED Item 3:**  
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Terms: swedge/swage, lubricate/lubricant, teflon, friction, coating,

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European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE,  
ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO,

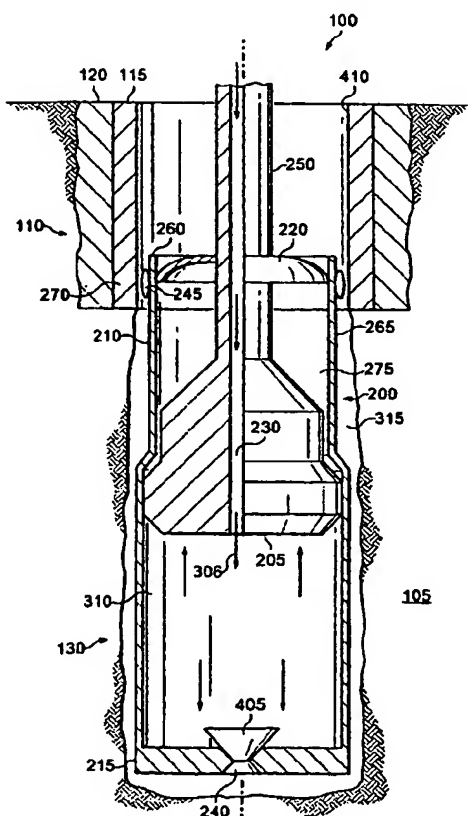
(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **SHUSTER, Mark**

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## AMENDED CLAIMS

[received by the International Bureau on 23 July 2004 (23.07.2004);  
claims 24-47 added]

17. The self-lubricating expansion mandrel of claim 12, wherein the solid lubricant retained in the plurality of troughs formed in a textured pattern comprises a thermo-sprayed coating.
18. The self-lubricating expansion mandrel of claim 12, wherein the depth of the plurality of troughs formed in a textured pattern is in a range of between about 50 and 150 microns.
19. A self-lubricating expansion mandrel for expanding a tubular member, comprising:
  - a housing including a tapered outer surface;
  - one or more grooves formed in the tapered outer surface; and
  - a grease supply chamber in the housing;
  - a conduit from the grease supply chamber to one or more of the grooves; and
  - means for forcing grease from the grease supply chamber through the conduit to one or more of the grooves.
20. The self-lubricating expansion mandrel of claim 19, wherein the one or more grooves comprise circumferential grooves.
21. The self-lubricating expansion mandrel of claim 19, wherein the grooves comprise axial grooves.
22. The self-lubricating expansion mandrel of claim 19, wherein the grooves comprise a pattern of grooves with both an axial and a circumferential component.
23. The self-lubricating expansion mandrel of claim 22, wherein the pattern of grooves comprises a textured surface.
24. A self-lubricating expansion mandrel for expanding a tubular member, comprising:
  - a housing including a tapered outer surface;
  - one or more grooves formed in the tapered outer surface; and
  - solid lubricant retained in one or more of the grooves;
  - wherein the grooves comprise circumferential grooves.
25. A self-lubricating expansion mandrel for expanding a tubular member, comprising:
  - a housing including a tapered outer surface;
  - one or more grooves formed in the tapered outer surface; and
  - solid lubricant retained in one or more of the grooves;
  - wherein the grooves comprise axial grooves.
26. A self-lubricating expansion mandrel for expanding a tubular member, comprising:
  - a housing including a tapered outer surface;
  - one or more grooves formed in the tapered outer surface; and
  - solid lubricant retained in one or more of the grooves;
  - wherein the grooves comprise a pattern of grooves with both an axial and a circumferential component.
27. A self-lubricating expansion mandrel for expanding a tubular member, comprising:
  - a housing including a tapered outer surface;
  - one or more grooves formed in the tapered outer surface; and

solid lubricant retained in one or more of the grooves;

wherein the pattern of grooves comprises a textured surface.

28. A self-lubricating expansion mandrel for expanding a tubular member, comprising:

a housing including a tapered outer surface;

one or more grooves formed in the tapered outer surface; and

solid lubricant retained in one or more of the grooves;

wherein the depth of the grooves is in a range of between about 1 and 4 microns.

29. A self-lubricating expansion mandrel for expanding a tubular member, comprising:

a housing including a tapered outer surface;

one or more grooves formed in the tapered outer surface; and

solid lubricant retained in one or more of the grooves;

wherein the depth of the grooves is in a range of between about 10 and 50 microns.

30. A self-lubricating expansion mandrel for expanding a tubular member, comprising:

a housing including a tapered outer surface;

one or more grooves formed in the tapered outer surface; and

solid lubricant retained in one or more of the grooves;

wherein the solid lubricant retained in one or more of the grooves comprises a thermo-sprayed coating.

31. A self-lubricating expansion mandrel for expanding a tubular member, comprising:

a housing including a tapered outer surface;

one or more grooves formed in the tapered outer surface; and

solid lubricant retained in one or more of the grooves;

wherein the depth of the grooves is in a range of between about 50 and 150 microns.

32. A self-lubricating expansion device for expanding a tubular member, comprising:

a housing including a tapered outer surface;

one or more depressions formed in the tapered outer surface; and

a lubricant supply chamber in the housing;

a conduit from the lubricant supply chamber to one or more of the depressions; and

means for forcing lubricant from the lubricant supply chamber through the conduit to one or more of the depressions.

33. The self-lubricating expansion mandrel of claim 32, wherein the one or more depressions comprise circumferential grooves.

34. The self-lubricating expansion mandrel of claim 32, wherein the depressions comprise axial grooves.

35. The self-lubricating expansion mandrel of claim 32, wherein the depressions comprise a pattern of grooves with both an axial and a circumferential component.



36. The self-lubricating expansion mandrel of claim 35, wherein the pattern of grooves comprises a textured surface.
37. A self-lubricating expansion device for expanding a tubular member, wherein the interface between the expansion device and the tubular member, during the expansion process, includes a leading edge portion and a trailing edge portion, comprising:  
a housing including a tapered outer surface;  
one or more first depressions formed in the leading edge portion of the tapered outer surface; and  
a lubricant supply chamber in the housing;  
a conduit from the lubricant supply chamber to one or more of the first depressions;  
means for forcing lubricant from the lubricant supply chamber through the conduit to one or more of the depressions;  
one or more second depressions formed in the trailing edge portion of the tapered outer surface; and  
a solid lubricant provided within one or more of the second depressions.
38. The self-lubricating expansion mandrel of claim 37, wherein one or more of the first and second depressions comprise circumferential grooves.
39. The self-lubricating expansion mandrel of claim 37, wherein one or more of the first and second depressions comprise axial grooves.
40. The self-lubricating expansion mandrel of claim 37, wherein one or more of the first and second depressions comprise a pattern of grooves with both an axial and a circumferential component.
41. The self-lubricating expansion mandrel of claim 40, wherein the pattern of grooves comprises a textured surface.
42. A method of lubricating the interface between an expansion device and a tubular member during an expansion of the tubular member using the expansion device, wherein the interface between the expansion device and the tubular member comprises a leading edge portion and a trailing edge portion, comprising:  
injecting a fluid lubricant into the leading edge portion; and  
providing a solid lubricant in the trailing edge portion.
43. A system for lubricating the interface between an expansion device and a tubular member during an expansion of the tubular member using the expansion device, wherein the interface between the expansion device and the tubular member comprises a leading edge portion and a trailing edge portion, comprising:  
means for injecting a fluid lubricant into the leading edge portion; and  
means for providing a solid lubricant in the trailing edge portion.
44. A method of lubricating the interface between an expansion device and a tubular member during an expansion of the tubular member using the expansion device, wherein the interface between the

expansion device and the tubular member comprises a leading edge portion and a trailing edge portion, comprising:

providing a supply of a fluid lubricant within the expansion device; and

injecting the fluid lubricant into the leading edge portion.

45. A system for lubricating the interface between an expansion device and a tubular member during an expansion of the tubular member using the expansion device, wherein the interface between the expansion device and the tubular member comprises a leading edge portion and a trailing edge portion, comprising:

means for providing a supply of a fluid lubricant within the expansion device; and

means for injecting the fluid lubricant into the leading edge portion.

46. A method of lubricating the interface between an expansion device and a tubular member during an expansion of the tubular member using the expansion device, wherein the interface between the expansion device and the tubular member comprises a leading edge portion and a trailing edge portion, comprising:

providing a supply of a solid lubricant on the expansion device within the trailing edge portion.

47. A system for lubricating the interface between an expansion device and a tubular member during an expansion of the tubular member using the expansion device, wherein the interface between the expansion device and the tubular member comprises a leading edge portion and a trailing edge portion, comprising:

means for providing a supply of a solid lubricant on the expansion device within the trailing edge portion.